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which are tapped through insulated narrow brass plates L, M, having thin plates of ebonite (with holes through which the studs project very slightly) on their under and upper surfaces respectively. The studs can thus be readily adjusted vertically to give good contact without interfering with the smooth motion of the vertical plate. For the adjustment of the instants of contact to the times of true transit over the wires, the right ascension micrometer of the transit-circle is used to move the wires so that they respectively bisect the artificial object when it is brought (by slowly turning the spindle of the screw which actuates the pulley wheel) into the respective positions for which contact is made by its stud with each of the studs corresponding to the wires. The readings of the R.A. micrometer are taken for the bisection of the artificial star by each wire, and the micrometer is set to the mean of the readings. A reversion-prism eyepiece is used in these adjustments to eliminate any personality in bisection of a stationary object. Thus the mean of the true times of transit over the wires is adjusted to agree precisely with the mean of the instants of contact with the corresponding studs.

In observations of limbs I propose to use an artificial star as a point of reference, measuring the distance between the artificial limb and star on the plate with a micrometer microscope, and also in the field of view of the transit-circle with the R.A. micrometer. The scale would be given by measuring the distance between two stars on the plate and in the field of the transit-circle. In this way personality in the bisection of a stationary limb would be determined, and the personality in observations of a first or second limb would be found by means of transits. It may be remarked that the reversion-prism eyepiece gives facilities for converting the preceding or following limb (*a* or *b*) into an upper or lower limb, so that personality in N.P.D. observations of limbs can be thus determined.

Plates with apertures representing the various planets may be substituted for any of the four *b*, *c*, *d*, *e*.

Royal Observatory, Greenwich:
1887, *November* 19.

Results obtained with the Personal Equation Machine at the Royal Observatory, Greenwich. By H. H. Turner, M.A., B.Sc.

A full description of the Personal Equation Machine is given by the Astronomer Royal in the preceding paper. Observations were made with this instrument in 1885 and 1886, but, owing to pressure of other work, little more was done than was necessary to test the general practicability of the measures. A series of transits of an artificial star was observed by several observers, the apparent rate of motion being a little greater than that of an equatorial star, and alternately towards

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the left (*l*), and towards the right (*r*). This reversal of apparent direction of motion can be obtained either by reversing the actual motion of the plate or by using the reversion-prism eyepiece with the transit-circle; and to eliminate certain errors, both methods were employed in combination. The letters *l* (towards the left of the observer) and *r* (towards the right) are always used to designate the resulting apparent direction of motion, the actual motion of the plate being defined by the letters E (towards the east) and W (towards the west). With the ordinary eyepiece the apparent motion is towards the left when the plate moves towards the east.

The transits were registered automatically on the chronograph which is used for ordinary star observation, the electromagnet usually connected with the clock being temporarily placed in the circuit connected with the instrumental studs. The record made by the observer was made exactly in the same manner as that for the transit of a star, except that the instrument was in a horizontal position and the observer standing erect, which only occurs approximately in the case of stars near the horizon.

The following are the results obtained for absolute personal equation, the sign + signifying that the observer is late in his record. The relative personal equation in use for all objects without distinction, and referred to Mr. Downing as standard observer, is placed in brackets after each observer's name for comparison. The initials H.T., C., A.D., T., L., H., S.D. and R., are those of Mr. Turner, Mr. Criswick, Mr. Downing, Mr. Thackeray, Mr. Lewis, Mr. Hollis, Mr. Dolman, and Mr. Robinson respectively.

Each printed number is the mean of a transit of nine wires.

Observer, H. T. ($-0^{s}{\cdot}15$.)

	Apparent Motion *l*.		Apparent Motion *r*.	
	E.	W.	E.	W.
	s	s	s	s
1885, Aug. 26	+0·07			+0·03
	+0·10			+0·04
	+0·31			+0·03
	+0·26			+0·11
	+0·09			+0·08
1886, May 9	+0·01	−0·02	−0·06	+0·14
	−0·02	+0·03	−0·01	+0·04
May 10	−0·04	−0·04	−0·01	−0·05
27	−0·06	−0·09	−0·09	−0·10
	+0·03	−0·16	−0·15	−0·12
Mean	+0·075	−0·056	−0·060	+0·020
Mean, excluding 1885, Aug. 26	−0·016	−0·056	−0·060	−0·018

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Observer C. (+0^{s}·28.)

	Apparent Motion *l.*		Apparent Motion *r.*	
	E.	W.	E.	W.
	s	s	s	s
1885, Aug. 26	+0·45			+0·35
	0·28			0·35
	0·34			0·28
	0·34			0·42
	0·34			0·26
1886, May 18	0·27	+0·22		0·14
	0·31	+0·22		+0·19
	0·25			
	+0·28			
Mean	+0·318	+0·220		+0·284
Mean, excluding 1885, Aug. 26	+0·278	+0·220		+0·165
Observer, A. D. (0^{s}·00.)				
1886, May 10	+0·12	+0·07	+0·14	+0·09
	+0·09		+0·06	+0·09
May 27	+0·20	+0·15	+0·20	+0·15
	+0·18	+0·18	+0·10	+0·15
Mean	+0·148	+0·140	+0·125	+0·120
Observer T. (−0^{s}·13.)				
1885, Aug.	+0·12			+0·11
	0·07			0·14
	+0·08			+0·13
1886, May 27	−0·07	−0·10	+0·03	−0·08
	−0·09	+0·01	+0·07	−0·11
Mean	+0·030	−0·045	+0·070	+0·038
Mean, excluding 1885, Aug. 26	−0·060	−0·045	+0·070	−0·095
Observer, L. (−0^{s}·01.)				
1886, May 18	+0·15	+0·15	+0·13	+0·18
	+0·11	+0·16	+0·16	+0·13
May 27	+0·09	+0·02	+0·01	+0·16
		+0·03	+0·09	
		+0·09	+0·11	
Mean	+0·117	+0·090	+0·100	+0·157

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Observer, H. (+0ˢ·23.)

	Apparent Motion *l.* E.	 W.	Apparent Motion *r.* E.	 W.
	s	s	s	s
1885, Aug. 26	+0·41			+0·39
	0·38			0·36
	0·37			0·39
	0·41			0·42
	0·36			0·39
1886, May 18	+0·49	+0·54	+0·41	0·51
				+0·47
May 27	+0·36	+0·19	+0·21	+0·40
	+0·28	+0·20	+0·22	+0·32
Means	+0·383	+0·310	+0·280	+0·406
Means, excluding 1885, Aug. 26	+0·377	+0·310	+0·280	+0·425
Observer, S. D. (−0·16.)				
1885, Aug. 26	+0·17			+0·44
	+0·15			0·19
	+0·32			0·10
	+0·01			0·18
	+0·13			+0·09
Mean	+0·156			+0·200
Observer, R. (+0·03).				
1886, May 9	+0·07	+0·26	+0·21	+0·19
	+0·03	+0·24	+0·19	+0·21
Mean	+0·050	+0·250	+0·200	+0·200

The results for 1885, August 26, have been separated from the others in the second set of means for each observer, because the reversion-prism eyepiece was not used on that day, and also because the general working of the instrument on this first occasion was not quite so satisfactory.

After these preliminary measures some time was spent in making better general arrangements before any detailed investigation was undertaken. Among other things it was considered advisable to use a different form of chronograph. With the one used for the above observations and for ordinary star work, a record consists of a single puncture only, made on drawing-paper by a sharp pricker, there being no sensible difference between an almost instantaneous tap and one where the contact is continued for a considerable fraction of a second;

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but it was felt to be desirable in the present instance to have a record of both the make and break of a contact. Accordingly a small chronograph, by Krille, which had been used for mechanical registration was adapted to electrical registration. The records are made by two pens which mark continuous lines round the barrel, except when drawn aside (one to the right and the other to the left) by the electro-magnets. It is found most convenient for reading off the transits to adjust the pens both to the same continuous line, placing one slightly in advance of the other. The distance between them affects every measure, and must therefore be very carefully observed. But by reversing the attachment of the electro-magnets, and placing that which was previously in the observing circuit now in the machine circuit, this distance between the pens enters into the observed measure of personal equation with the opposite sign; and this reversal which is performed by the observer in the middle of his observations on any day, thus eliminates any error in estimation of the distance.

Towards the end of June of the present year a systematic series of observations was undertaken by the four regular transit-circle observers for the determination of the change of personal equation with apparent rate of motion. The method of conducting the observations was as follows:—

A suitable artificial star on the brass plate having been selected, the corresponding stud is brought up from the west into contact with the stud corresponding to the first wire of the transit-circle by an assistant at the instrument, who turns the spindle of the driving-screw very slowly until the click of the electro-magnet on the chronograph is heard. This operation is generally repeated very carefully after the first click has indicated the approximate position for contact. When a satisfactory contact has been obtained, word is given to the observer at the transit-circle, who then bisects the artificial star with the first wire by means of the R.A. micrometer-screw, and records the reading. Two bisections are considered sufficient. The assistant at the instrument is then directed to pass to the second wire, at which the process is repeated, the stud being now bisected with the second wire of the transit-circle so that the reading of the R.A. micrometer is nearly the same. It would be exactly the same as the former if the interval between the portions of the two wire-studs with which the star-stud came in contact were the exact equivalent of the interval between the wires in the transit-circle. Observation shows that the wire-studs have been so well adjusted to these equivalent intervals that a condition to be presently mentioned is fulfilled. The above process is repeated for all the nine wires, and the mean of the 18 nearly equal readings (2 for each wire) of the R.A. micrometer is then taken. If now the micrometer be set to this mean reading, which for the moment we will suppose to apply accurately to each of the 9 wires, and the plate carrying the artificial star and its stud be

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set in motion from west to east, an observer with zero personal equation would record the transit of the star at each wire exactly at the same instant at which contact is made by the star-stud with the corresponding wire-stud, and the pens in the instrumental and observing circuits would be deflected simultaneously. If the pen in the observing circuit is deflected later than the other, the observer is considered to have a positive personal equation. The condition referred to above is that the bisection and contact should be for every wire very nearly simultaneous; otherwise the records of the observer and machine would be made at sensibly different points of the star's path, and it is possible that this might introduce small errors.

Before, however, any transits are observed in this way, the above process of "taking adjustments," as it has been called, is repeated for the other side of the studs; that is to say, the star-stud is brought up from the east, so that the artificial star moves towards the west and appears to the observer to move towards his right. Another set of eighteen similar readings of the R.A. micrometer is thus obtained, the mean of which can be used in exactly the same way for setting the micrometer so that with reversed motion the ideal observer would record simultaneously with the machine. As a general rule, throughout the whole series of observations, the transits and adjustments were made in corresponding pairs with motion E and motion W.

After the observations for "adjustment" a number of transits —generally about a dozen with each direction of motion—were taken, the rate of motion being changed after every pair. This rate is controlled by the position of the brass disc on its spindle; and the spindle is graduated in twentieths of an inch to the right and left of a zero which corresponds to zero rate of motion. It was found by preliminary experiments that if the brass disc be set to the reading 22^{d}·0, the apparent rate of motion of the artificial star is the same as that of an equatorial star, and accordingly the following settings of the spindle were selected for trial: 33^{d}·0, 22^{d}·0, 16^{d}·0, 11^{d}·0, 6^{d}·0, 3^{d}·0. The first of these corresponds to a rate half as large again as that of an equatorial star, while the remaining settings correspond to the rates of motion of stars at N.P.D. 90°, 43½°, 30°, 15°, and 9° respectively. The last of these readings was after a few trials discarded as inconveniently slow for use in the present investigation. The succession of readings on any day was selected arbitrarily, so as to avoid any possible influence of systematic change of rate. Between separate transits, while the disc was being carefully set on the spindle by the assistant at the instrument, the observer recorded several consecutive seconds on the chronograph to indicate the time value of the chronograph scale on the particular day. This was necessary because the chronograph was somewhat exposed to the wind, and controlled merely by a fan governor; and it was found impossible to avoid small changes of rate. The mean of all the scale values thus indicated on any day has generally been adopted for

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the reduction of the observations on that day, but sometimes, where it is clear that the chronograph has changed its rate during the observations, the observations on that day have been separated into groups. In any case the influence of slight changes of rate in the chronograph on the result obtained is very small.

The clock used to give the second signals was the transit clock, Hardy, which stands directly behind the observer and ticks loudly. The observer can thus without much trouble note the whole time of transit of the star to the nearest second, and since 1887, Sept. 8, this has been made the practice. Information was thus accumulated, first, as to the accuracy of the correspondence between the spindle setting $22^{d}\cdot0$ and equatorial rate; and secondly, as to the legitimacy of the assumption that the rate at which the brass disc was driven varied directly as the distance from the centre of the circular plate. In both cases the result was satisfactory [see note (5) at the end of the paper].

After a number of transits had been observed, the 'adjustments' were repeated exactly in the same order as at first, and the set of observations was complete. The process of reading off the differences in time recorded by the observer and by the machine, and of reducing the observations, is so simple as not to require further explanation; and we may give at once the concluded results for absolute personal equation, arranged with the spindle setting as argument.

The probable error of a complete transit is found from the residuals to be $0^{s}\cdot030$, $0^{s}\cdot035$, $0^{s}\cdot044$, $0^{s}\cdot056$, $0^{s}\cdot093$ at the various spindle settings respectively; and from these numbers the probable errors given in the table have been deduced.

The number of transits observed in each case is given in brackets.

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Absolute Personal Equation at Spindle Settings.

Obsr.	Direction of Motion.	33^{d} —		22^{d} Equatorial Rate.		16^{d} Rate at N.P.D. $43\frac{1}{2}°$.		11^{d} Rate at N.P.D. 30°.		6^{d} Rate at N.P.D. 15°.	
		s	s	s	s	s	s	s	s	s	s
H. T.	*l*	−0·053	±0·013 (6)	−0·065	±0·015 (6)	−0·098	±0·020 (5)	−0·115	±0·028 (4)		
		-0·063	±0·013 (6)	−0·043	±0·015 (7)	−0·048	±0·020 (5)	−0·045	±0·028 (4)		
A. D.	*l*	+0·094	±0·007 (18)	+0·064	±0·008 (19)	+0·045	±0·011 (15)	+0·036	±0·014 (15)	+0·052	±0·026 (13)
	r	+0·072	±0·007 (17)	+0·075	±0·008 (19)	+0·065	±0·011 (15)	+0·076	±0·015 (14)	+0·137	±0·026 (13)
T.	*l*	−0·042	±0·006 (26)	−0·077	±0·007 (25)	−0·108	±0·009 (22)	−0·158	±0·014 (17)	−0·109	±0·024 (15)
	r	−0·044	±0·006 (26)	−0·036	±0·007 (25)	−0·062	±0·009 (22)	−0·069	±0·014 (18)	−0·019	±0·024 (15)
L.	*l*	+0·020	±0·006 (25)	+0·003	±0·007 (22)	+0·003	±0·010 (20)	−0·008	±0·012 (21)	−0·077	±0·022 (18)
	r	+0·013	±0·006 (24)	+0·021	±0·008 (20)	+0·014	±0·010 (20)	+0·036	±0·013 (20)	+0·093	±0·022 (17)
H.	*l*	+0·221	±0·007 (18)	+0·256	±0·007 (23)	+0·260	±0·012 (14)	+0·316	±0·013 (19)	+0·457	±0·023 (16)
	r	+0·234	±0·007 (19)	+0·267	±0·007 (23)	+0·274	±0·012 (14)	+0·349	±0·013 (19)	+0·528	±0·024 (15)

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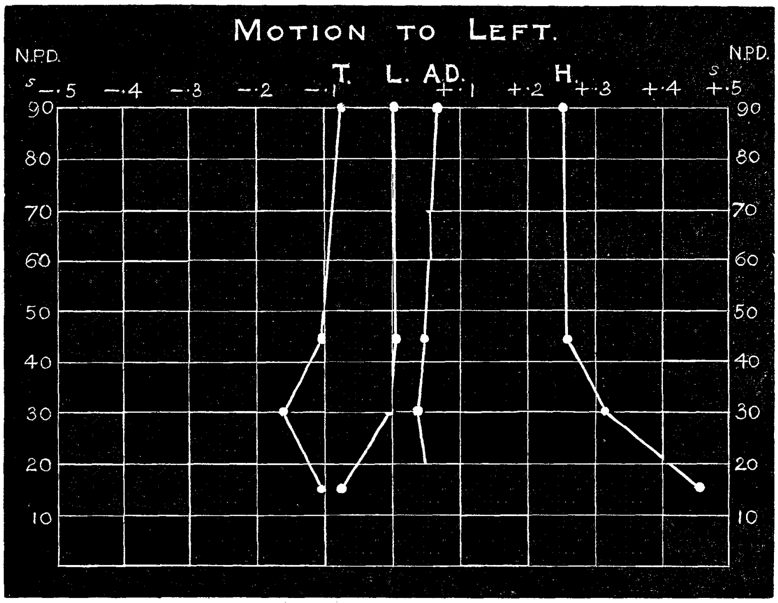
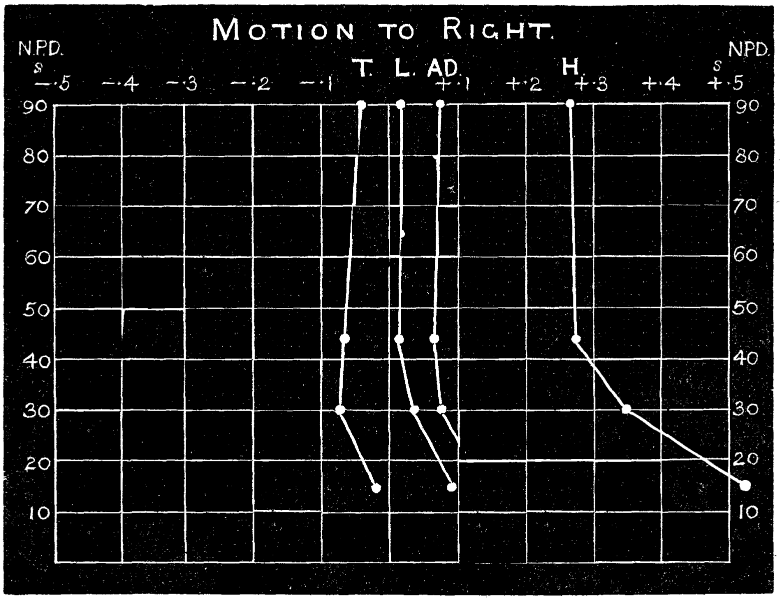
The following diagrams exhibit these results graphically for the four regular observers, and for rates of motion which occur in actual star observing. The whole width of each diagram represents a second of time, and the curve corresponding to each observer is to the right or left of the centre according as he is late or early in his record. The rate of motion is indicated by the corresponding N.P.D. for a real star.





The probable errors for a single transit do not increase directly as the rate of motion decreases; on reducing them to the equator the series of numbers becomes

$0^{s}\cdot045$ $0^{s}\cdot035$ $0^{s}\cdot032$ $0^{s}\cdot028$ $0^{s}\cdot025$.

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so that the observations at slower rates are more accurate. These "reduced" probable errors are represented very accurately by the formula

$$\text{Prob. error} = 0^{s}{\cdot}022 + 0^{s}{\cdot}0132 \times \frac{\text{spindle-setting}}{22},$$

so that the actual probable error is

$$0^{s}{\cdot}022 \times \frac{22}{\text{spindle-setting}} + 0^{s}{\cdot}0132.$$

Of these two quantities the first is a constant error in *arc*, and the second in time. The first probably represents the error of bisection of the star's image, and the second the error the observer is liable to make in trying to tap at a definite instant.

The probable error of the transit of an equatorial star observed over nine wires as found by Mr. Dunkin (*Monthly Notices*, vol. xxiv.) is $0^{s}{\cdot}017$; and the probable error of a result for right ascension is $0^{s}{\cdot}034$, the difference being due to errors in the determinations of the position of the transit-circle.

The determinations of personal equation above tabulated are fairly comparable with the second kind of measure; for here also various instrumental errors of adjustment are added to those of simple errors in transit observing. It is satisfactory to find such a close agreement between the deduced probable errors for a complete transit in the two cases.

The results for personal equation are checked at various points by other investigations:

A. The *relative* personal equations for clock-stars are investigated annually in the "Greenwich Observations." The standard observer is A. D. Till recently the direction of motion was always *l*, but the reversion-prism eyepiece has been used since 1884 June, for the observation of two clock-stars with apparent motion *r* on every fine night. The great majority of clock-stars are however still observed with the ordinary eyepiece, i.e. with apparent motion *l*, and the mean rate is a little less than equatorial—corresponding to a spindle setting of about 21^{d} instead of 22^{d}.

Selecting then the proper numbers from the above results for comparison with the relative personal equations we get

Obs.	Absolute P.E.	P.E. relative to A. D.	Difference = A. D.'s abs. P. E.
	s s	s	s
H. T.	−0·07 ± 0·015	−0·15	+0·08
A. D.	+0·06 ± 0·008	...	+0·06
T.	−0·08 ± 0·007	−0·13	+0·05
L.	+0·00 ± 0·007	−0·01	+0·01
H.	+0·26 ± 0·007	+0·23	+0·03
		Mean	+0·05

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The small discrepancies in the quantity found in the last column are quite consistent with a probable error of about $0^{\mathrm{s}}{\cdot}010$ in each of the quantities between which it is the difference.

B. Besides these relative personal equations between different observers we have for comparison two sets of independently determined differences between the personal equations for the same observer with motion *l* and motion *r* respectively. The first set is deduced from comparison of clock errors obtained from observations with the transit-circle using the reversion-prism eyepiece.

Extracting in the same way the required differences $(r-l)$ from the table, for spindle reading 21^{d} we get

	From Machine results.	From Star results.	No. of Determinations.
	s s	s s	
H. T.	+0·027 ± 0·020	−0·035 ± 0·011	12
A. D.	+0·014 ± 0·012	+0·010 ± 0·004	70
T.	+0·042 ± 0·010	+0·063 ± 0·012	28
L.	+0·017 ± 0·011	+0·020 ± 0·004	72
H.	+0·011 ± 0·011	+0·010 ± 0·004	85

The number of determinations given in the last column indicates the number of nights on which clock-stars were observed with the reversion-prism. Usually two were observed on each night, but the transits were generally over four wires only. The probable errors are deduced from the residuals of the results for each night.

The second set of measures of the same quantity for stars moving rather more slowly was made with the altazimuth, the same star being observed at practically the same transit with both directions of apparent motion.

Taking out the differences for spindle reading 16^{d} as most suitable for comparison, we have for differences $(r-l)$:

	From Machine results.	From Altaz. results.
	s s	s s
H. T.	+0·050 ± 0·022	+0·041 ± 0·020
A. D.	+0·020 ± 0·011	+0·030 ± 0·012
T.	+0·046 ± 0·010	+0·039 ± 0·017
L.	+0·011 ± 0·010	+0·047 ± 0·013
H.	+0·014 ± 0·011	−0·015 ± 0·009

The agreement may be therefore considered satisfactory.

Returning to the consideration of the table of absolute personal equations, the chief point to be considered is the effect these small differences, hitherto neglected, would have on the Greenwich right ascensions. As regards clock-stars, whose rate of motion varies from that corresponding to spindle setting $22^{\mathrm{d}}{\cdot}0$ (equatorial) to $17^{\mathrm{d}}{\cdot}3$ (*α Lyræ*), it appears that two of the regular observers, L. and H., do not vary in habit between these limits, but that the

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other two change nearly $0^{s}\cdot02$ and $0^{s}\cdot03$ in the same direction, so that the mean of the four observers would give correct results within $0^{s}\cdot01$ for the whole range.

As regards the stars catalogued, some of which move slowly and some have reversed direction of motion, the average effect is not quite insensible, the mean personal equation for the four observers being as below:—

N.P.D.		90°	43½°	30°	15°
Motion	*l*	+0·062	+0·050	+0·047	+0·081
"	*r*	+0·082	+0·073	+0·098	+0·185

There does not appear to be any general law representing the change of personal equation with rate. We might suppose the personal equation to be made up partly of error of bisection and partly of a constant error in time, either deliberate or unconscious. We should expect the latter not to vary with the rate or direction of motion, and the former to vary inversely as the rate and to change sign with the direction of motion. This is fulfilled approximately for all the observers except H., whose "error of bisection" amounting to nearly $1''\cdot0$ does not change sign with the direction of motion; so that in this case the observer apparently waits until the star has travelled about $1''$ past the wire—whatever be the direction of motion—and then "hangs fire" for about $0^{s}\cdot2$ before the record is complete. Such a well-marked exception rather precludes generalisation.

The quantities to be measured are all so small that their determination is originally liable to several sources of systematic error. The following notes on some special points may be of interest:—

(1) *Systematic error in reading off the transits.*—With the exception of two occasions, on which the observer read off his own transits, the differences were all read off by Mr. Downing. Any systematic error would then be presumably common to the whole series. But the precaution adopted of interchanging the circuits in the middle of the observations almost certainly eliminates any error of this kind. For instance, if Mr. Downing reads off every distance on the chronograph too large by $0^{d}\cdot01$ of the scale (each of the ink lines defining this distance is several times this quantity), the first group of deduced personal equations would be all too large by $\frac{0^{s}\cdot007}{S}$, where S is the ratio of the spindle setting to $22^{d}\cdot0$; but the second group would be all too small by the same quantity, and hence this error is practically eliminated in the mean result for each day.

(2) *The error in measurement of the distance between the pens* has been already referred to, and is eliminated in the same manner as in (1).

(3) *Permanence of the positions for contact between the studs.*—This is one of the most vitally important points in the working of the instrument, and one of the most satisfactory. The studs

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are cylinders carefully rounded at the ends, so that the contact surfaces are approximately hemispheres. The upper stud is lowered until it will touch one of the lower set when about $0^{in}{\cdot}01$ (corresponding to about $3''$) to the left or right of it; and consequently remains in contact with it for about $0^{in}{\cdot}02$ as it is carried over it. There is accordingly a slight lifting of the plate carrying the artificial star whenever one of the studs attached to it passes over one of the fixed studs; but so long as the above approximation of the studs is not exceeded, no appreciable interruption to the smoothness of the transit is discernible. Had this been the case, the difficulty could have been got over by giving the star-stud a small freedom of motion in a vertical direction relatively to the plate, the attachment being made by means of a spring instead of being rigid. But no such arrangement is found necessary, for the jerkiness in transit, noticeable when the duration of contact is large, disappears when it is adjusted as above to a total length of about $0^{in}{\cdot}02$ (corresponding to about $6''$) in the transit-circle telescope; or, in other words, when the difference of readings of the R.A. micrometer for bisection of the artificial star when its stud is brought into contact from the left and right respectively is about $0^{r}{\cdot}400$. The mean value of this quantity found from all the observations is $0^{r}{\cdot}470$. On the other hand, if the length of contact is initially adjusted to much less than this, the contact is liable to fail after a number of transits owing to a little rubbing down of the points, or slight strain, or possibly some electrical action at the points of contact. Such changes are detected by measurements of the length of contact registered in transit, and by comparison of the adjustments taken after the transits with those taken before; and the position of a single stud for contact is rarely found to vary as much as $0^{in}{\cdot}005$ (corresponding to $1''{\cdot}5$). In preliminary experiments with the machine the changes had been somewhat larger and much more irregular, but from experiments made by Mr. Lewis, June 10–22, a large part of the disturbance was traced to the Sun's heat when sunlight was used to illuminate the star, the Sun's rays having also fallen on the studs, no doubt causing irregular expansion. On taking care to screen these portions of the instrument, the changes were immediately reduced in magnitude, and part of the apparent irregularity still remaining is no doubt error of observation. It is found, however, that the mean effect is a slight shortening of the contacts, the action being evenly distributed at the two ends, as might be expected from the symmetrical arrangement. The mean of this "wear" on the 32 days of observation is $0''{\cdot}33$ on the right and $0''{\cdot}36$ on the left, or a total shortening of $0''{\cdot}69 = 0^{in}{\cdot}0023$ in the whole length of a contact. On one day only was the mean wear for the 9 studs so much as $1''{\cdot}5 = 0^{in}{\cdot}005$, and on many days it was insensible.

Since the R.A. micrometer is set throughout the transits to readings determined by the first set of adjustments, the effect of

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this receding of the contacts, which a discussion of the lengths of contact registered in transit shows to be gradual, is to attribute to the observer a gradually increasing personal equation, and a small correction becomes requisite. Where the total change is so small, however, it was considered sufficient to correct the transits as though the true position for contact were throughout the mean of those indicated by the two sets of adjustments.

(4) The distance between positions for contact on the right and left, i.e. the length of contact, is also registered on the chronograph. It is interesting to compare the value of this length as recorded by the deflection of the chronograph pen when the stud is in continuous motion with the value obtained by means of the R.A. micrometer in the position of rest. Special observations were taken with this object on June 22 and June 27, and the observations made on several subsequent days have been also discussed.

The following table shows the mean value of the length of a contact for one stud, as shown by the "adjustments" (in second column) and from registers on the chronograph for both directions of motion in the next column:—

Date.	Adjustments.	Transits.
	"	"
June 22	5·81	5·65
27	6·22	5·70
July 18	5·99	5·47
21	4·86	4·98
Aug. 1	4·82	5·58
Sept. 8	2·90	4·64
9	6·25	6·47
Mean	5·26	5·70

The small difference thus indicated is readily explicable on the assumption of a very slight sticking together of the studs for a small period longer than consistent with absolutely uniform motion. It was expected that such a sticking would have a constant time-value, and thus affect the more rapid rates of motion relatively to the slower. The observations on available days were accordingly collected under the various rates of motion with the following result:—

Spindle Setting.	Length of Contact.
d.	"
33	5·36
22	5·42
16	5·58
11	5·50
6	5·30
Adjustments	4·96

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There is thus no great difference between the duration of contact for slow and quick rates.

Part of this small discrepancy between measures at rest and in motion is possibly due to systematic error in reading off the chronograph intervals.

(5) The correspondence of the spindle setting $22^{\mathrm{d}}\cdot 0$ to equatorial rate has been carefully tested. On the earlier days one of the intervals between the wires of a transit was read from the chronograph. The equatorial value of this interval is $2^{\mathrm{s}}\cdot 811$. The mean value of this interval in time for the various rates of motion is as follows:—

d	d	d	d	d	d
33·0	22·0	16·0	11·0	6·0	3·0
s	s	s	s	s	s
1·801	2·753	3·691	5·404	9·913	20·650

or, reduced to the corresponding value at reading $22^{\mathrm{d}}\cdot 0$,

s	s	s	s	s	s
2·702	2·753	2·684	2·702	2·704	2·816

To obtain the second line it is assumed that the rate varies inversely as the spindle setting.

It was found, however, that, owing to the variations in rate of the chronograph, this was not a satisfactory method of measuring the rate of transit. The individual observations show large discrepancies, which would amply explain the above small differences in the means. The practice mentioned above was subsequently adopted of observing the whole time of transit to the nearest second. The mean results are as follows:—

	d	d	d	d	d
Spindle setting	33	22	16	11	6
	s	s	s	s	s
Motion *l* ...	19·08	27·81	37·93	54·02	96·88
Motion *r* ...	18·81	27·91	37·92	54·36	100·09

or, reducing to reading $22^{\mathrm{d}}\cdot 0$,

	s	s	s	s	s
l	28·62	27·81	27·69	27·01	26·15
r	28·22	27·91	27·68	27·18	27·02

The equatorial interval of the transit wires being $27^{\mathrm{s}}\cdot 642$, the correspondence of the setting 22^{d} to equatorial rate may be considered satisfactory.

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Note on the Probable Errors of the Star Places of the Argentine General Catalogue for 1875, *and the Cape Catalogue for* 1880.

By A. M. W. Downing, M.A.

As a supplement to my paper on the star places of the Argentine General Catalogue for 1875, and the Cape Catalogue for 1880, printed in the *Monthly Notices* for last June, the following values of the probable errors of a difference of the catalogue places at different N.P.D.s. may be of interest. In the calculation of these probable errors it has not been thought necessary to make use of all the available material, but only of that resulting from the comparison of the places of stars of R.A. 0^{h}–1^{h}, 6^{h}–7^{h}, 12^{h}–13^{h}, and 18^{h}–19^{h}.

The following table gives the results of the computation :—

N.P.D.	No. of Stars.	Probable Error of a Single $\Delta\alpha$	Probable Error of a Single $\Delta\alpha$ sin N.P.D.	Probable Error of a Single $\Delta\delta$
° °		s	s	″
90–100	38	±0·050	±0·052	±0·76
100–110	36	±0·064		±0·62
110–115	91	±0·048		±0·57
115–120	194	±0·054		±0·51
120–125	207	±0·059		±0·56
125–130	194	±0·068	±0·051	±0·56
130–135	200	±0·065		±0·54
135–140	181	±0·074		±0·46
140–145	194	±0·089	±0·047	±0·47
145–150	178	±0·084		±0·50
150–155	133	±0·088		±0·48
155–160	93	±0·111	±0·041	±0·55
160–165	84	±0·127		±0·71
165–170	63	±0·201	±0·043	±0·52
170–180	47	±0·291	±0·025	±0·62

The mean value of the probable error of a single $\Delta\alpha$ sin N.P.D. is $\pm 0^{s}\cdot047$; and, assuming that the star places in the two catalogues are equally free from accidental errors, we find that the probable error of a R.A. in either $= \pm 0^{s}\cdot033$ expressed in equatorial time. The mean value of the probable error of a single $\Delta\delta$ is $\pm 0''\cdot55$; and, on the same assumption, it follows that the probable error of a N.P.D. in either catalogue $= \pm 0''\cdot39$. It appears, however, from Herr Backlund's investigations (*V. J. S.* 20 Jahrgang, III. Heft) that the probable errors of a single Cape observation in R.A. and N.P.D. are $\pm 0^{s}\cdot046$ cosec N.P.D. and $\pm 0''\cdot61$ respectively, and as each place in the Cape Catalogue depends, on the average, on 3 observations, we have the probable